# NASA Program Flavor

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## PHMTech09

with contributions from members of the IVHM and FDIR program and
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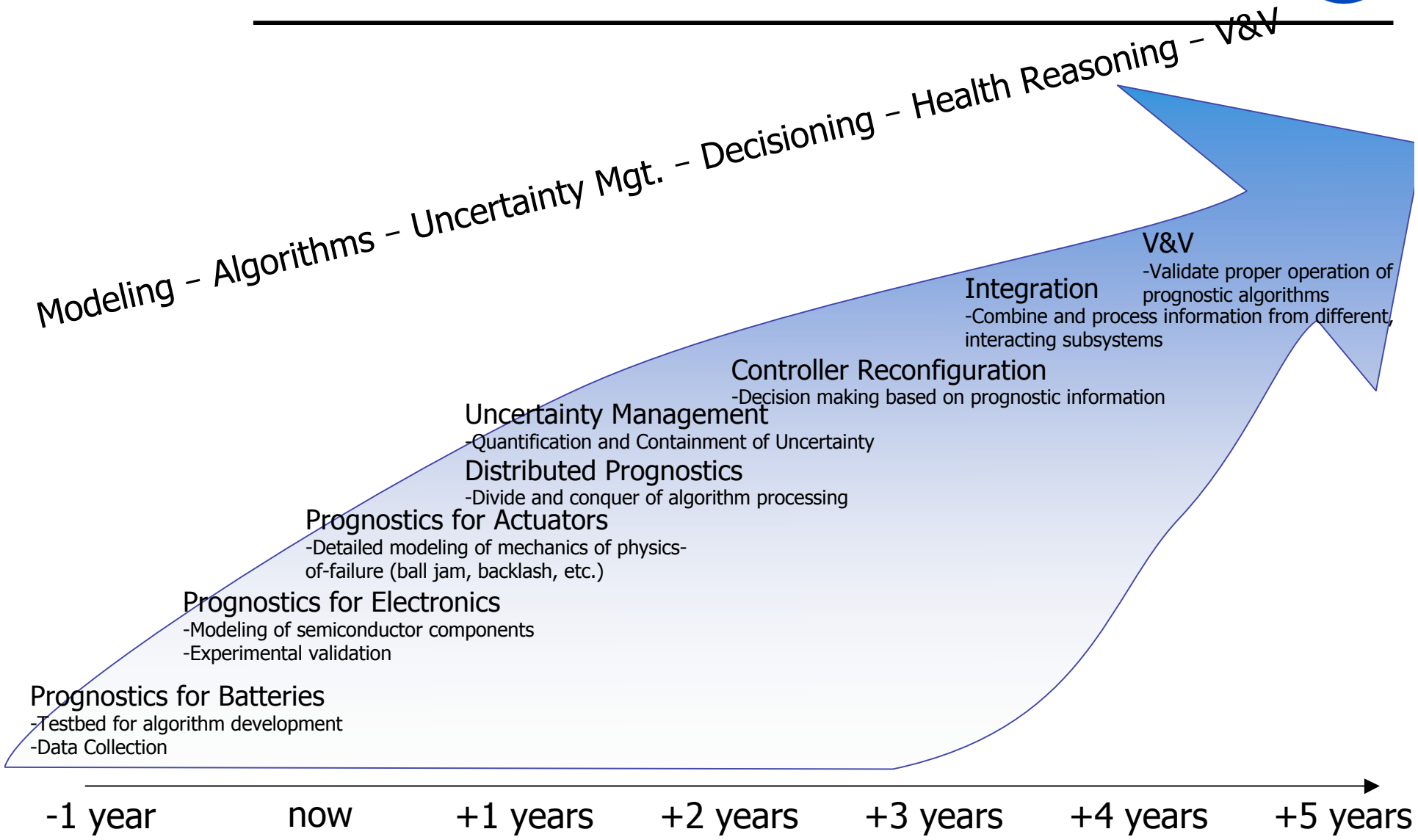
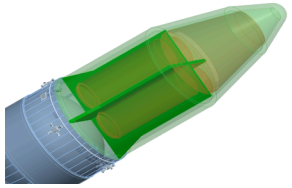
# Roadmap for Prognostics CoE



# Some Current NASA Activities in SHM

## ROCKET ENGINE TEST STAND

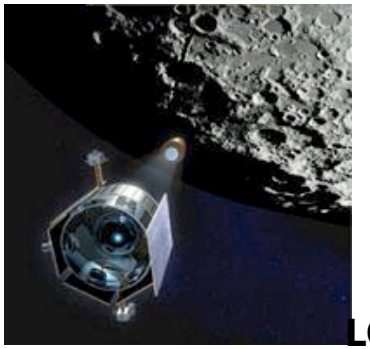
## HUMAN SPACE FLIGHT



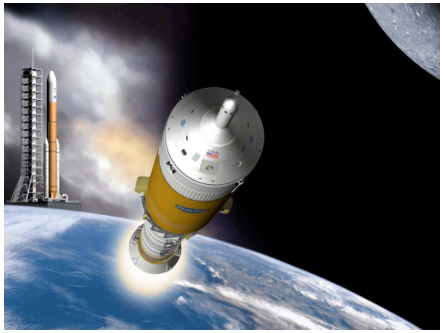
Composites Shroud

Ground Diagnostics for CLV and Ground Test / Integration Infrastructure

## ROBOTIC SPACE FLIGHT

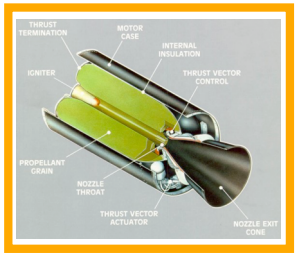


**LCROSS**
Ground-Based Root Cause Determination; Data Analysis



CLV Crew Abort Logic Development

Space Station Fault Analysis




Solid Rocket Motor Failure Detection and Prediction

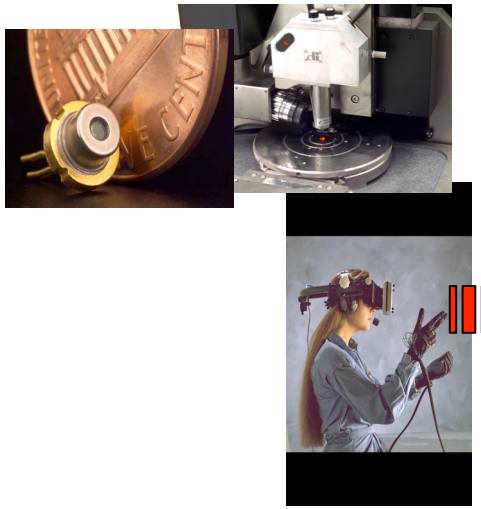
## AERONAUTICS

**IVHM**
On-board and off-board Diagnostics, Prognostics, Logistics

Space Shuttle Main Engine Abnormal Condition Detection

Data Analysis / Mining for Mission Ops

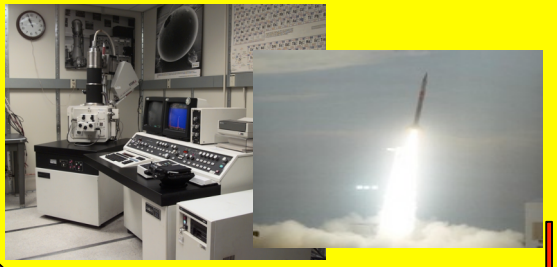
# Integrated Systems Health Management Implementation Concept

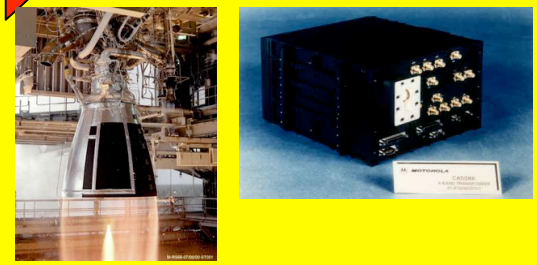


***Technology Development***

**ESMD, ARMD, SMD**

***ISHM***







***Highly Integrated Technologies Tested in Relevant Environments***

***NASA Missions***

**High Flight Maturity**

***Tech. Leverage***

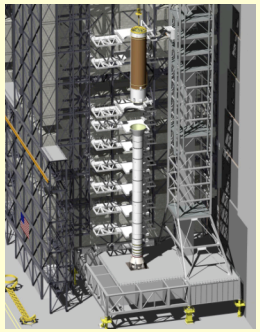
- **Industry-Supplied Technologies**
- **Commercialization Opportunities**

# FDIR Project

•Refurb of the Aft Skirt
• Integration of the Forward Assembly
•Hot fire of the Aft Skirt HPU

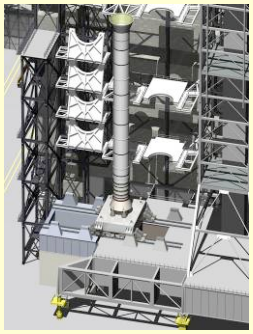
•Refurbishment and packaging of parachutes

•Recovery of spent booster, parachutes, and forward skirt extension
•Inspection & Disassembly of booster



•Stacking preps of segments
• Stacking & integration of segments
•Integrated Test
•Ordnance Operations and closeouts

•Receiving, processing, and surge of loaded motor segments
• Integration of the Aft Skirt with the aft motor segment



•Stacking preps of segments
• Stacking & integration of segments on pedestal
•Transfer of Ares I to ML
•Integrated Test
•Ordnance Operations and closeouts

**Fault Detection, Isolation and Recovery**

• Pad connections and validations
• Final ordnance ops
•Cryo load (refueling) and launch count

# FDIR Task Objectives

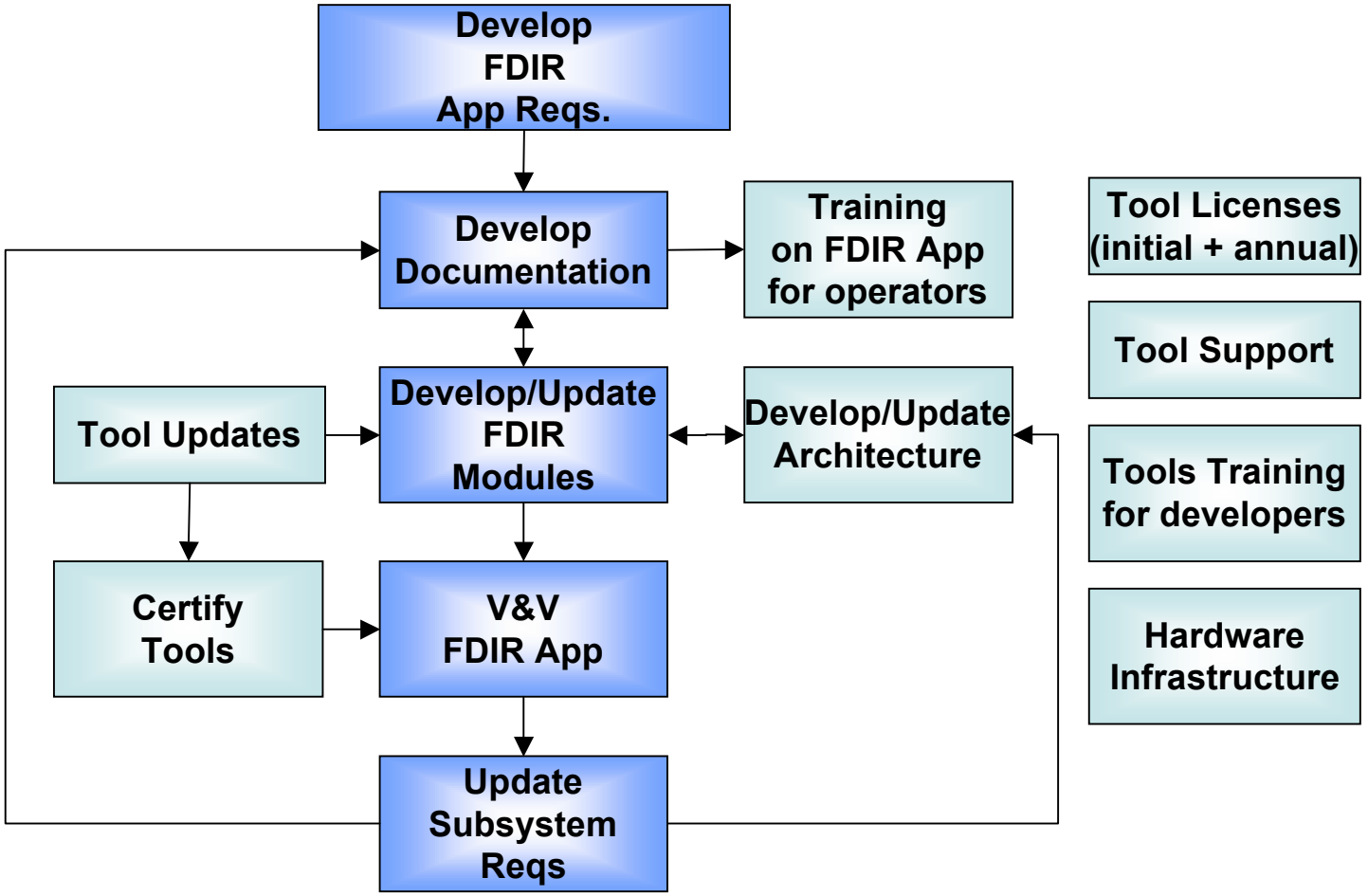

- Select and mature ISHM tools to provide anomaly detection, fault isolation and fault recovery recommendation for CxP ground operations
  - Help meet launch availability rate through faster fault isolation and recovery recommendation
- Develop architecture for integrated fault detection, isolation and recovery (vehicle and ground)
- Identify path for integration of ground and vehicle fault models
- Identify path for certification of the FDIR architecture
- Assess FDIR capability
  - Scalability, Performance, Cost, Benefit
- Initiate proof-of-concept for ground subsystem prognostics applications
- Provide implementation/deployment options for integration with the Launch Control System

# Integrated FDIR Concept


Deployment in phases

- Initial deployment
  - Capabilities
    - Anomaly Detection
    - Fault Detection and Fault Isolation
  - An FDIR application for the Liquid Hydrogen ground subsystem will be developed and validated within the Launch Control System
  - Requirement
    - Confirm tools will provide a "health/self-test" capability.
    - Minimize the risk to the other deployment activities
- Longer term deployment goals
  - Mature automated recovery recommendation capability
  - Mature prognostic capabilities for LRUs
    - Condition Based Maintenance vs. Reactive, Time-based Maintenance
  - Deploy FDIR capabilities to ground subsystems
  - Integrate vehicle and ground FDIR capabilities

# FDIR Application Lifecycle




Key:

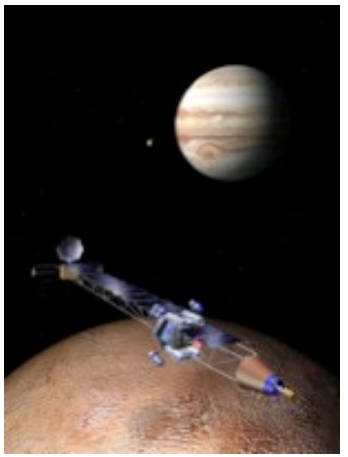
Per Subsystem

One time / Infrequent

# What Are the Hurdles?


- Application-specific
  - Short time horizon
- Corporate culture
  - New technology has to buy its way on
- Competing with other functions
  - No interference ("do no harm")
  - Weight
- S&T
  - Learning and adaptive systems
  - Software complexity
  - Decision Making
  - Uncertainty Management

# Summary and Conclusions



- Health management is seen more and more as an enabler for aerospace applications
- Ongoing activities at NASA cover range of HM areas
- Needs
  - Research methodology
  - Overcome challenges in S&T
    - Learning and adaptive systems
      - Space is the "final frontier" for ISHM
    - Software complexity
      - V&V, certification
    - Uncertainty Management
      - Credible methods to manage uncertainty
    - Decision Making
      - Tie-in to logistics; reconfiguration
- Implementation will be slow and painful, often one small step at a time
  - Finding the right applications is crucial
  - Ground ➔ Aircraft ➔ Robotic craft ➔ Human space flight
  - Increasing level of comfort and confidence over time
  - Proving benefit over cost
  - Taming software complexity
- Overcome bottlenecks in academia, government, industry
  - Vision: coordination of programs, technology development, education

# International Conference of PHM Society 2009


Call for Papers & Participation

**International Conference of PHM Society 2009**

September 28 – October 1, 2009

www.phmconference.org

This conference provides an international forum dedicated to Prognostics and Health Management (PHM). The conference continues the tradition to bring together experts from industry, academia, and government in diverse application areas such as energy, aerospace, transportation, automotive, and industrial automation. The conference is sponsored this year by the newly founded PHM Society and technical sponsorship of the IEEE CIS.

The conference will feature

**keynote** presentations by senior leaders in the field,

**panel** discussions,

**hardware demonstrations**,

**luminaries session**,

**doctoral consortium,**

dedicated session on **fielded systems**,

full day of **tutorials** free to all registrants.

Leading companies and research institutions will exhibit their products and demonstrate their technologies during the event. Several social events will provide opportunities for participants to connect with colleagues across the globe.